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AIDRET-V-1-0-0: User's Manual

Manual for Using

the

***A**gricultural **I**rrigation **D**emand **R**esponse **E**stimation **T**ool (**AIDRET**)*

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1 Introduction

1.1 What is AIDRET?

The Agricultural Irrigation Demand Response Estimation Tool (AIDRET) is a user-friendly, interactive public tool that was developed as an online standalone calculator that can be used to estimate demand response (DR) potential based on the model of the pumping load. It can be accessed via any browser at http://cec-aidret.lbl.gov:6024/index/.

AIDRET is designed to be used by those contemplating applying to investor-owned utility (IOU) DR programs. It enables users to estimate how much DR might be approved for their farm and the dollar amount of incentives that might be available. The tool also provides external resources that users can access to learn more about pumping efficiency, overall irrigation efficiency, and their irrigation system/crop mix.

1.2 About this Manual

This manual complements the tool's help menus and provides a more detailed explanation of the input parameters, understanding the results, and how the DR calculations are carried out. AIDRET's help menus (indicated by at the end of each input line) provide additional information about each input parameter, and clickable links provide additional information from external resources. Educational and discussion material can be accessed either from the tool's landing page or from the results page.

2 Getting Started

2.1 Landing Page

AIDRET's landing page presents a high-level overview of the tool's features and target audience. It also provides links to the educational material discussed in Section 3 of this manual. Figure 1 shows the landing page. Click on the "PROCEED" button on the bottom of the page to be directed to the main calculator's data entry screen.

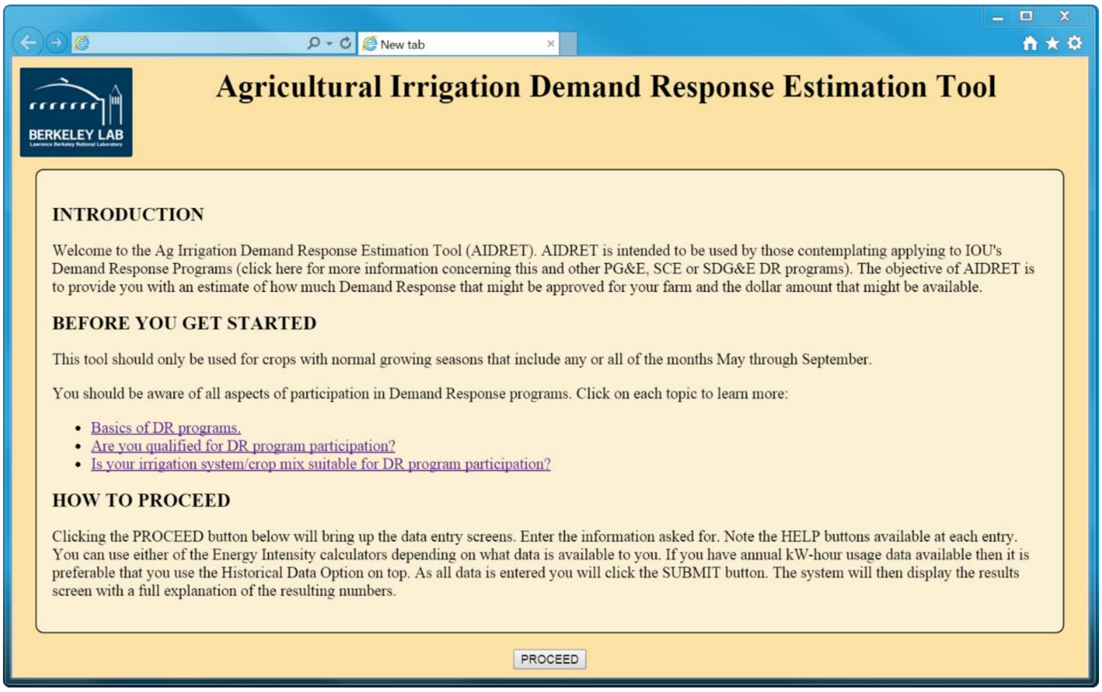


Figure 1. Tool's landing page as it appears on an IE7 browser

2.2 Data Entry Screen

The data entry screen features two calculators: "Demand Response Estimator" on the left and "Energy Intensity Calculation Options" on the right. Figure 2 shows this data entry page.

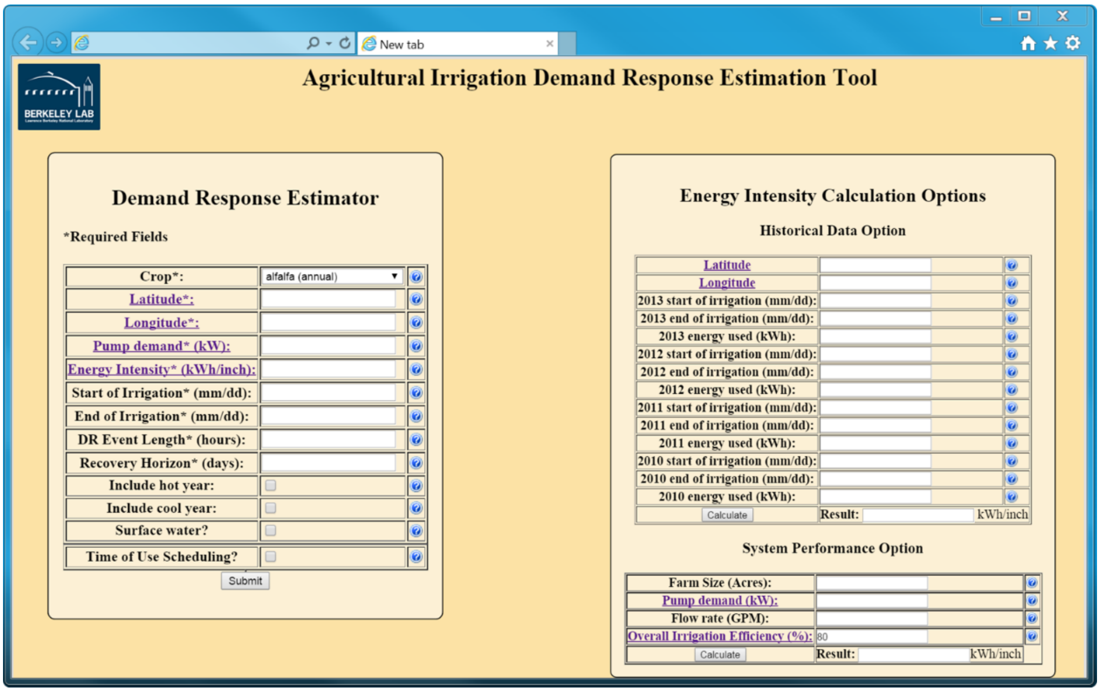


Figure 2. Data entry screen

2.2.1 Demand Response Estimator

Figure 3 shows the Demand Response Estimator (DR Estimator)—the main data entry menu used for DR availability calculations. This section describes the meaning of each input parameter and how they can be obtained in case they are not readily available. Input parameters labeled with an asterisk (*) are required, so leaving them empty will result in an error message.

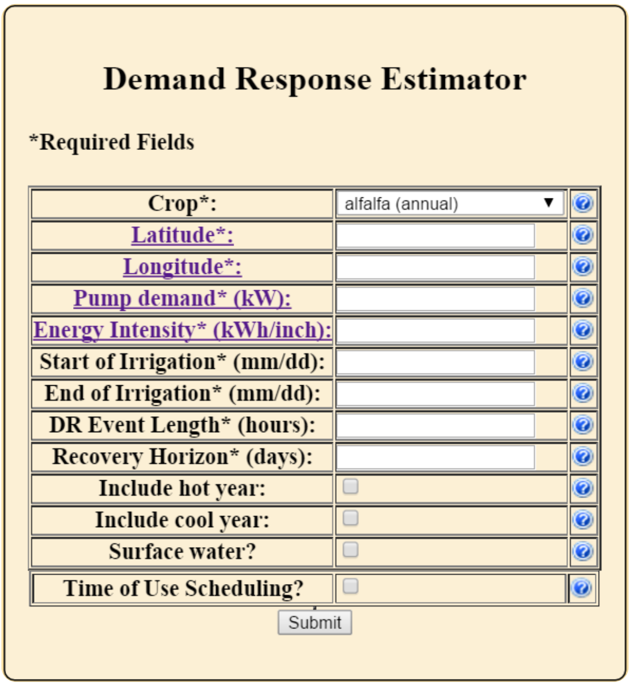


Figure 3. Main calculator for estimating DR availability

2.2.1.1 Crop*

Select from the drop-down menu the type of crop you are planting from the list of 65 available crops. If the crop is not listed, select alfalfa. Alfalfa has a crop coefficient (K_c) value of 1 and is usually used as a reference crop. The tool at its current stage cannot accept multiple crops and pumps. In case of a multi-crop/pump farm, use the tool multiple times for different crop/pump combinations.

2.2.1.2 Latitude* and Longitude*

Approximate latitude and longitude of the farm is required to determine farm's location. This should be the average values for the enrolled area. If these numbers are not known, clicking on the labels "Latitude" and "Longitude" will open a link[1] that will allow you to enter your ZIP code, city, or farm's full address for conversion. These numbers are used to choose the California Irrigation Management Information System (CIMIS) station that will supply reference evapotranspiration (ET) and average rainfall data. California's latitude spans from 32° to 42° (North) and its longitude extends from -114° to -124° (West). A geographic location outside of California will result in an error message. Except for the minus sign in the longitude input, latitude and longitude should be entered in numbers only. Adding letters (i.e., "N" for North and "W" for West) in the input box will result in an error. Figure 4 shows how the GPS Visualizer can be used to convert a ZIP code into latitude and longitude numbers.

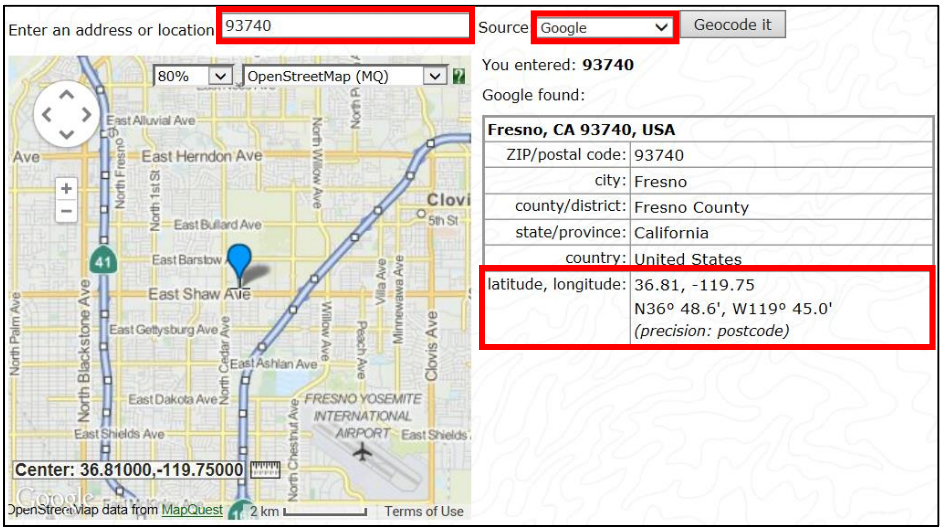


Figure 4. Example for converting ZIP code to latitude and longitude using the GPS Visualizer website (Source: http://www.gpsvisualizer.com/geocode)

[1] GPS Visualizer. http://www.gpsvisualizer.com/geocode

2.2.1.3 Pump Demand*

Pump demand is found on the farm's utility bill. This value is not the farm's total load, since not all the electricity used on the farm is due to water pumping. It may be referred to as *Connected Load, Billing Demand,* or even *Generated Demand.* AIDRET is looking for the maximum kilowatts (kW) of demand for the enrolled pump(s). Increasing this number will generally increase the available DR. Clicking on the input label will direct you to the Advanced Pumping Efficiency Program's (APEP) webpage. APEP can help you determine your pump demand through a pump test and help you identify ways to reduce that number by increasing your pumping efficiency.

2.2.1.4 Energy Intensity*

This is the amount of energy (in kilowatt-hours) it takes to apply an inch of water over the area covered by the enrolled pump. Increasing this number for a fixed pump demand tends to decrease the available DR. If the energy intensity of the farm is not known, that number can be calculated using the Energy Intensity Calculation Options that accompany the DR Estimator. Energy Intensity Calculation Options are described in more detail in Section 2.2.2.

Clicking on the input label will take you to an e-learning website[2] developed by the Center for Irrigation Technology (CIT) and California Water Institute (CWI) at Fresno State University. The e-learning website has resources that you can use to learn more about water management, pumping efficiency, irrigation system pressure, and rate schedules—as well as ways to improve irrigation practices.

2.2.1.5 Start* and End* of Irrigation

Typical start and end of irrigation should be entered in mm/dd format. These set the period which the enrolled pump(s) will be used to supply water to your selected crop. Lengthening this window tends to increase the available DR. These values might change annually, depending on the weather and type of crop. For default values regarding crop planting and harvesting dates, refer to Appendix I.

2.2.1.6 DR Event Length*

This is the length of time in hours that the enrolled pump(s) will be shut off when asked. It can be 2, 4, 6, and possibly 8 hours depending on the program. Events typically occur weekdays during the months of May through October, from 12:00 pm

[2] Fresno State Center for Irrigation Technology, Advanced Pumping Efficiency Program. http://www.californiawater.org/elearning/story.html

to 6:00 pm (although 11:00 am to 12:00 pm and 6:00 pm to 7:00 pm are recently emerging as popular time frames for DR within the grower community). The effect of changing this number depends on how close the pumping capacity is to the water requirements. Smaller numbers tend to decrease available kilowatts (and vice-versa) if the pumping capacity is close to water requirements. The reason behind this correlation is explained in more detail in Section 4.2.

2.2.1.7 Recovery Horizon*

Recovery Horizon (RH) is the length of time that the crop can tolerate low soil moisture before becoming permanently damaged, reported in number of days. In other words, it is the maximum amount of time before soil moisture returns to pre-event conditions. This is the amount of time in which the deferred pumping has to be made up (i.e., for the soil moisture to reach pre-demand-response levels). Longer RH results in higher DR availability.

2.2.1.8 Include Hot and Cool Years (Optional)

Selecting the option for a hot or cool year will add a column to the results table indicating available DR in a hot year. In the back-end calculations, a *hot year* is defined as a year with one standard deviation higher ET compared to the average past three years. This will result in more available DR, as a grower is likely to pump more in on-peak periods. Similarly, a *cool year* is defined as a year with one standard deviation lower ET compared to the average past three years. This will result in less available DR, as a grower is likely to pump less in on-peak periods.

2.2.1.9 Surface Water Usage (Optional)

Once you check the surface water box (shown in Figure 5), the input list will expand, asking for the percentage of surface water as the total required irrigation water. This is the amount of irrigation water (in percentage) that is supplied by surface water, and requires no pumping. Increasing the amount of surface water decreases the amount of available DR, as it reduces well pumping. This will be zero if the enrolled pump is a booster pump.

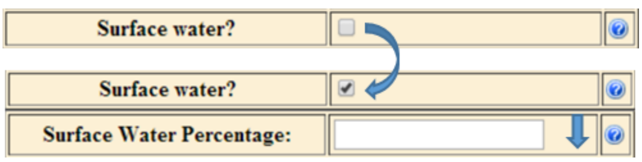


Figure 5. Selecting surface water and entering the percentage of irrigation water supplied by that source

2.2.1.10 Time-of-Use Scheduling (Optional)

Select the Time of Use Scheduling option if the farm modifies its irrigation pattern to take advantage of time-of-use (TOU) electricity pricing. This will be used to more accurately determine the DR availability, since the farm is already curtailing its demand during peak hours. Once this option is selected, as shown in Figure 6, the expanded input will ask you to define the number of hours at which you are billed at a higher rate and what percentage of your energy demand falls within those peak hours. The higher the percentage now pumping on-peak, the smaller the available DR. Many programs have certain requirements for current on-peak operations to be eligible.

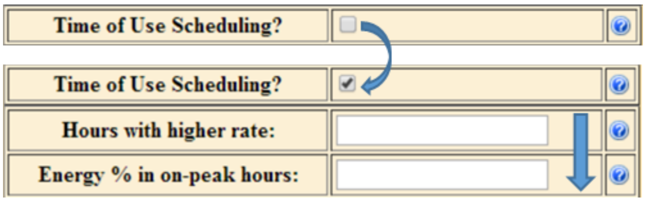


Figure 6. The inputs required once Time of Use Scheduling is selected

2.2.2 Energy Intensity Calculation Options

There are two options for calculating your farm's energy intensity. This value is the DR Estimator's fourth required input, discussed in Section 2.2.1.4. You can use either of the Energy Intensity Calculator Options, depending on which data are available to them. If annual kilowatt-hour usage data are available, then it is preferable to use the Historical Data Option at the top of the box. If historical usage data are not available, the System Performance Option, in the lower portion of the box, can be used. Figure 7 shows the interface of the energy intensity calculator and a flow chart of how the energy intensity is calculated.

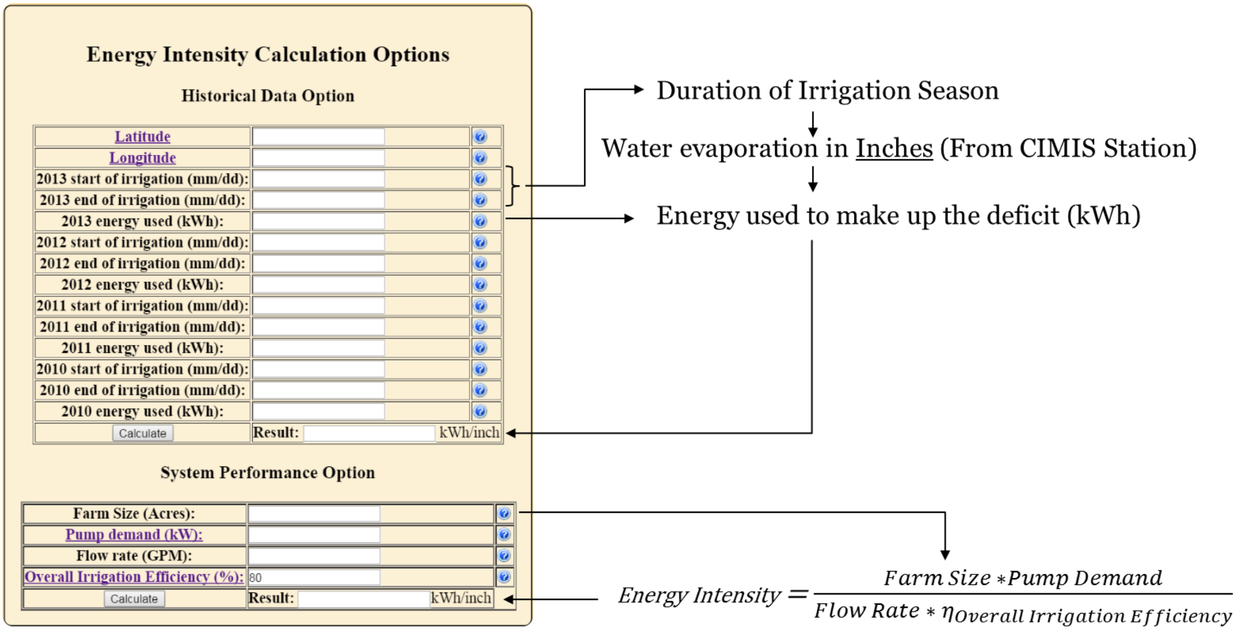


Figure 7. Energy intensity calculator (left) and an explanation of how the energy intensity is calculated (right)

2.2.2.1 Historical Data Option

The Historical Data Option (top calculator) uses historical energy consumption data to determine the farm's energy intensity. The historical energy intensity is calculated by looking at the cumulative ET from the CIMIS station during the irrigation period in inches of water, and the total energy applied to satisfy water requirements. Then the total energy is divided by the cumulative ET to find the energy intensity in kilowatt-hours per inch. The calculator can also use multi-year inputs, summing each year's energy and ET before calculating the ratio. Previous analysis has shown using at least three years of data results in minimum error.

2.2.2.2 System Performance Option

The system performance method for calculating Energy Intensity uses farm size, pump demand, flow rate, and overall irrigation efficiency to calculate the energy intensity. Farm size input is in acres and refers to the crop area covered by the enrolled pump(s). The pump demand is the same number as the one used for the input in Section 2.2.1.3. If you do not know the actual pump demand, click the input label, and it will redirect you to the APEP[3] website, where you can request a pump test. There is no universal value for irrigation and distribution efficiency, but Overall Irrigation Efficiency of 80 percent is easily achievable. If you do not know the overall

[3] Advanced Pumping Efficiency Program
http://www.pumpefficiency.org/Pumptesting/costanalysis.asp

irrigation efficiency, click on the input label to go to CIT's irrigation scheduling website,[4] with detailed information on overall irrigation efficiency.

2.3 Results Page

Figure 8 shows sample input values for a 160-acre cotton farm in Fresno, California. For demonstration purposes, both energy intensity calculators were used to calculate the energy intensity of this farm. The energy intensity values calculated by each option might differ, depending on the accuracy of the input values, but they should be in close agreement with each other if accurate values are entered.

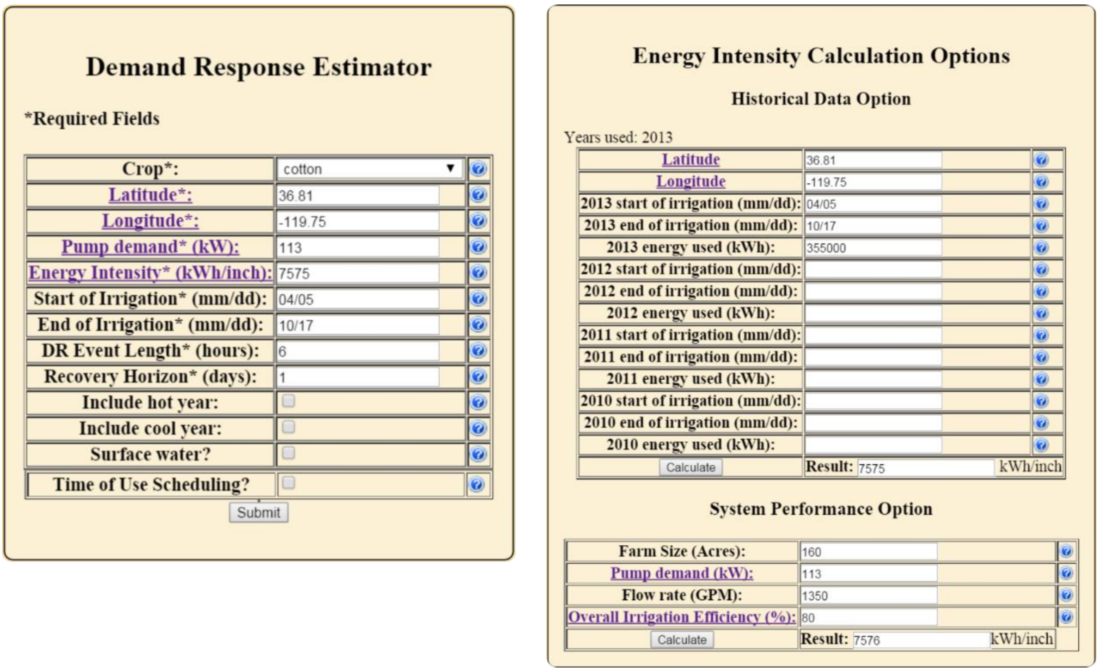
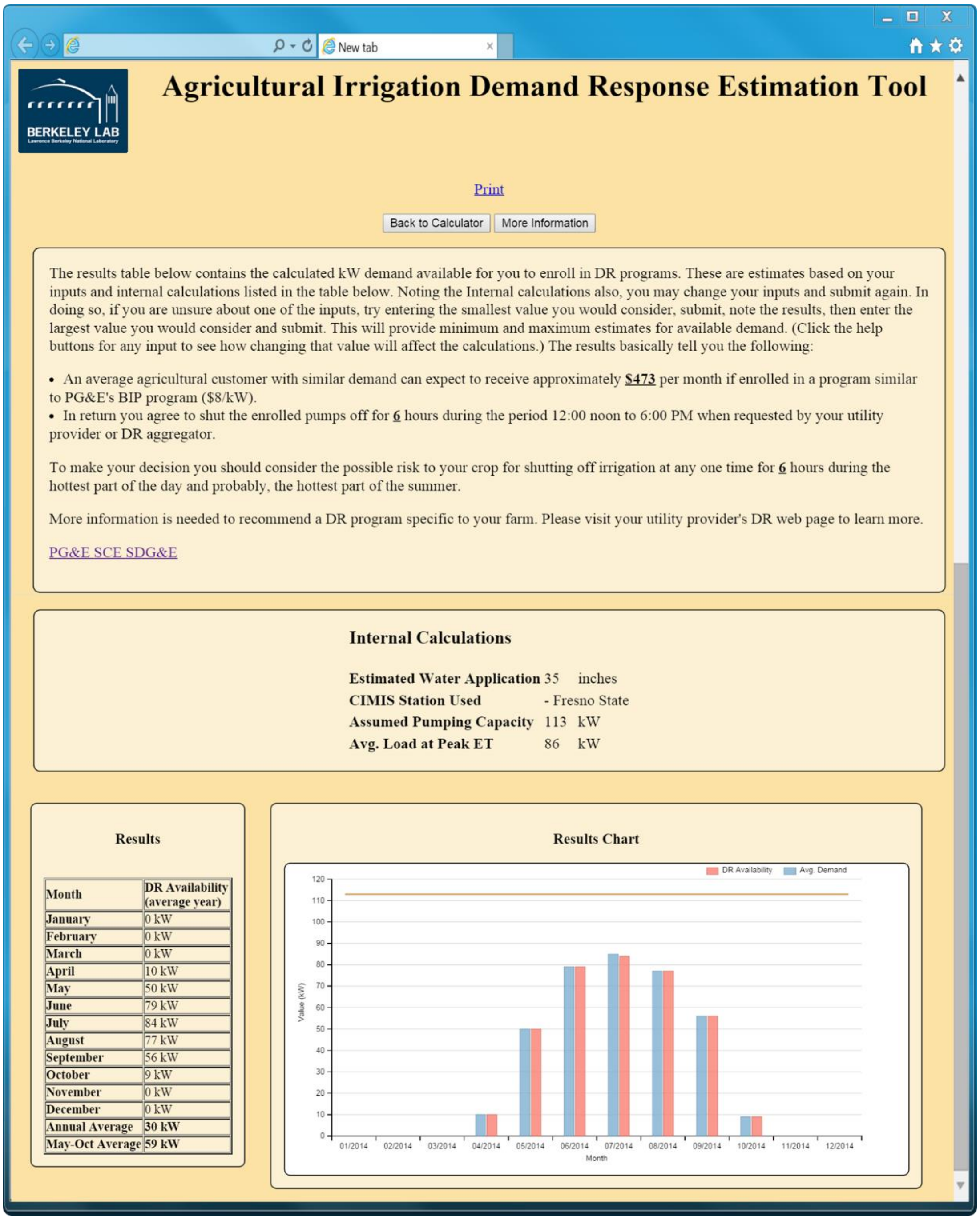


Figure 8. Sample input values for a cotton farm in Fresno, California

Once all the required fields labeled with asterisks (*) are complete, click the "Submit" button to get to the results page. An example is shown in Figure 9.

[4] Wateright. www.wateright.org



New tab

Agricultural Irrigation Demand Response Estimation Tool

BERKELEY LAB

Print

Back to Calculator | More Information

The results table below contains the calculated kW demand available for you to enroll in DR programs. These are estimates based on your inputs and internal calculations listed in the table below. Noting the Internal calculations also, you may change your inputs and submit again. In doing so, if you are unsure about one of the inputs, try entering the smallest value you would consider, submit, note the results, then enter the largest value you would consider and submit. This will provide minimum and maximum estimates for available demand. (Click the help buttons for any input to see how changing that value will affect the calculations.) The results basically tell you the following:

- An average agricultural customer with similar demand can expect to receive approximately $473 per month if enrolled in a program similar to PG&E's BIP program ($8/kW).
- In return you agree to shut the enrolled pumps off for 6 hours during the period 12:00 noon to 6:00 PM when requested by your utility provider or DR aggregator.

To make your decision you should consider the possible risk to your crop for shutting off irrigation at any one time for 6 hours during the hottest part of the day and probably, the hottest part of the summer.

More information is needed to recommend a DR program specific to your farm. Please visit your utility provider's DR web page to learn more.

PG&E SCE SDG&E

Internal Calculations

Estimated Water Application	35	inches
CIMIS Station Used	- Fresno State	
Assumed Pumping Capacity	113	kW
Avg. Load at Peak ET	86	kW

Results

Month	DR Availability (average year)
January	0 kW
February	0 kW
March	0 kW
April	10 kW
May	50 kW
June	79 kW
July	84 kW
August	77 kW
September	56 kW
October	9 kW
November	0 kW
December	0 kW
Annual Average	30 kW
May-Oct Average	59 kW

Results Chart

Figure 9. AIDRET results page

The calculator's output is shown in two text boxes: a table and a chart, as shown in Figure 9. Depending on your browser settings, you may need to scroll down to see the entire results page. The paragraphs in the top text box explain the meaning of the results and translate your farm's DR availability into dollar values, assuming an $8/kW incentive. The second text box provides some assumptions used in the internal calculations, based on your input. Use the values in this box to check that you have entered the correct input parameters. On the bottom of the results page, you will see a table (on the left) with average monthly DR availability and a graphical representation of those same results (on the right). The gold line above the bars that show DR availability and average demand marks the farm's assumed pumping capacity. If you selected hot and cool years in the inputs, the results will show two columns (hot and cool years) in addition to the average year DR availability, and the graph will show those extra series as well.

DR availability in the results is the potential load shed that could be achieved if an event were called in a specific month (e.g., if a DR event were called for the farm represented in Figure 9 in July, it would be expected to shed 85 kW for a six-hour DR event). Depending on the farm's recovery horizon, the expected load shed could drop as consecutive DR events were called.

Using the options above the first text box (Figure 9), you can print the results or save them as a PDF file, navigate back to the calculator, or click on "More Information" to learn more about the results. Section 3 discusses the material that you will go through if you click on the "More Information" button.

3 Understanding the Results

In most demand response programs, incentives are given on a "per-kilowatt of enabled load" basis. However, the magnitude of the load that is truly enabled is up for debate. Most pumps do not run continuously, so they are not always available to respond to DR events. Therefore, the maximum pumping capacity needs to be de-rated before utilities or aggregators can calculate the incentive to pay for the enrolled pump(s). This tool serves to provide an estimate for that purpose. In addition the tool provides links to external resources and discussions that can help you learn more about improving your pumping and irrigation systems.

3.1 Basics of Demand Response Programs

Demand response programs are basically an agreement between electricity consumers and the utility that says: **"Customers will turn off their pump(s) during certain time periods when the utility asks them to, and in return, the utility will pay them a certain amount of money."**

These programs involve many factors:

- **The period within which the pumps must be off.** Generally this period will be between 12 noon and 6:00 pm, but it may extend from 11:00 am to 7:00 pm.
- **How long the pumps must be off during this period.** Some programs give customers an option of 2, 4, 6, or even 8 hours. Others will specify the length.
- **How much lead time the utility provides.** Some programs are "day ahead" programs, and some are "day of" the event. Some will specify a set period throughout the season.
- **Requirements for current operations.** This will differ among programs. For example, some programs require customers to be pumping at least 70 percent in on-peak hours currently in order to qualify.
- **Noncompliance.** Some programs penalize customers who do not turn off their pump(s).

3.2 Demand Response and Crop Risks

It is important to understand the terms and conditions of the DR program that you are contemplating. Some DR programs will specify the maximum number of times per season that they may call on customers to shut off pumps. Some may specify that they will not make a request for turn off two days in a row—possibly even only once in a seven-day period. Others may be more restrictive in the idea that they may call for a shut-off two or more days in a row, depending on the situation. Users of this tool and customers have to ask themselves: *"How much is it going to cost me to shut off when I am asked to?"* No one can answer these types of questions except the grower.

3.2.1 Irrigation System Type

A good way to begin thinking about this issue is to consider whether the farm's irrigation system is considered a high-frequency (HF) or low-frequency (LF) system. High-frequency systems apply water frequently, with examples being any kind of micro-irrigation system, including drip, sub-surface drip, foggers, sprayers, or mini-sprinklers. Low-frequency systems apply water infrequently, with examples being furrow or border strip irrigation systems.

The important distinction between HF and LF systems is that the intent of an HF system is to maintain a near-optimum soil moisture level. An HF system maintains a rather high soil moisture content throughout the season; with a LF system, the soil moisture goes through more of a distinct wet-to-dry process. As shown in Figure 10. the soil moisture for the LF system alternates between very wet and very dry between each of the six irrigation events. The very dry condition occurs just before another irrigation. Note also that the length of the wet-dry cycle tends to compress throughout the season as the weather heats up and the crop uses water at a faster rate.

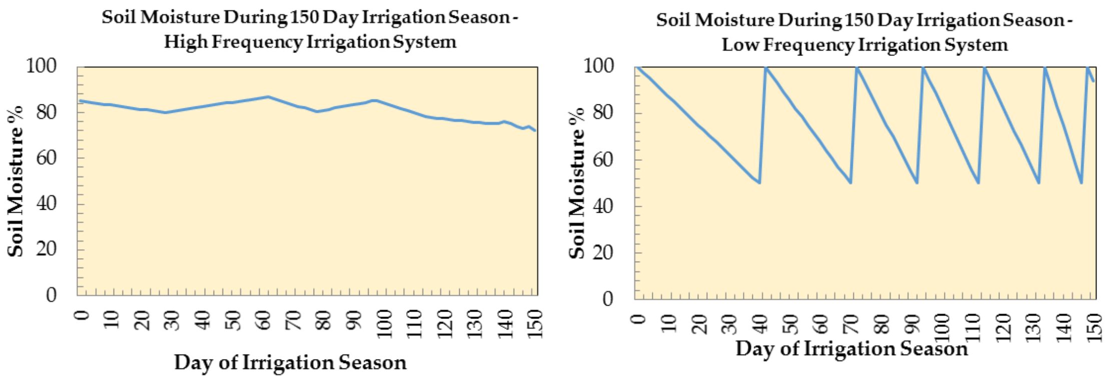


Figure 10. Time-dependent soil moisture levels for high frequency (left) and low frequency (right) irrigation systems for a 150-day period

The point of this discussion is to make clearer the consequences of shutting off irrigation pumps when asked. For the HF system it may not be much of an imposition, especially with excess pumping capacity. For example, if the HF system was asked to turn off for four hours, or even two days in a row, the reduction in soil moisture would not necessarily impact crop quality/yield at all. And, with excess capacity, soil moisture would be able to return to optimum levels quickly.
On the other hand, if a DR program required pump shut off for more than two days

in a row using the LF system, and that request occurred at the beginning of an irrigation cycle, it could cause soil moisture levels to drop to a point that would impact crop quality/yield.

3.2.2 System Capacity

Another important factor is *system capacity.* We use the term as a means of identifying how fast the irrigation system can apply water versus how fast the crop is using that water. Excess capacity makes it easier to "play catch-up" if soil moisture gets too low. For example, some kind of irrigation system failure or possibly other field operations may conflict with ideal time to irrigate, with the result being that the soil moisture is reduced too much. With excess capacity, soil moisture can return to ideal levels quickly.

4 Calculating Demand Response Potential

AIDRET's calculation of DR potential is based on a model of the pumping load. This load model is based on the location of the field, the crop grown, planting and harvest dates, the energy intensity of the pumping, and the equipment capacity. Once crop water requirements are determined, the energy intensity and equipment capacity are used to build a load profile.

4.1 Basic Irrigation Scheduling (BIS)

The location, crop, planting, and harvest dates are used to estimate the crop water requirements, using the methods contained in the Basic Irrigation Scheduling (BIS) software developed by:

- R. L. Snyder, University of California, Land, Air and Water Resources, Davis, California
- M. Orang, California Department of Water Resources, Division of Planning, Sacramento, California
- K. Bali, University of California, Cooperative Extension, Imperial County, Holtville, California
- S. Eching, California Department of Water Resources, Office of Efficient Water Use, Sacramento, California

The BIS software can be found at:
http://biomet.ucdavis.edu/irrigation_scheduling/bis/BIS.htm.

Figure 11 indicates water losses that are considered in BIS method and the losses that are no taken into account.

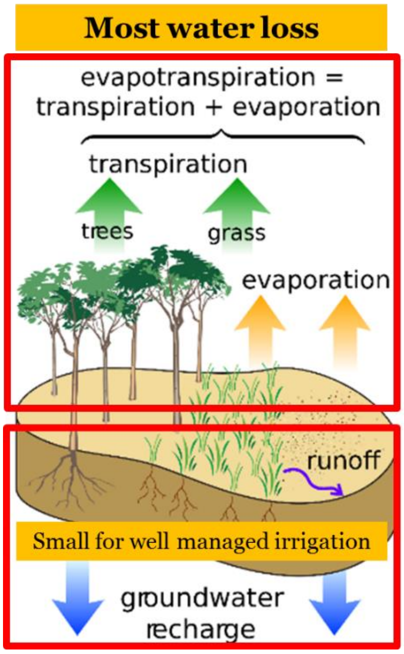


Figure 11. Basic Irrigation Scheduling focuses on water losses through evapotranspiration

In a well-managed irrigation system, water runoff and percolation (groundwater recharge) are minimized, and most water losses come from evapotranspiration (ET)—the combination of evaporation of water from soil surfaces and transpiration of water through the plant. Evapotranspiration rates are influenced by a range of environmental factors, and measured in inches per day. It is the driving force behind irrigation, as the water applied to crops has to approximate water lost to the environment to maintain soil moisture in a range that promotes good crop growth.

4.1.1 Crop Coefficient Curve

Calculating demand response potential involves a series of steps. First, a crop coefficient curve (Kc) is constructed for the selected crop, based on planting and harvest dates, as seen in Figure 12. The crop coefficient accounts for crop morphology, crop physiology, and irrigation management. Values of the crop coefficient at certain points in the growing season are provided; dates are specified as percentages of the growing season in the Kc columns in Appendix I (Note that Kc_A = Kc_B). The values in between the specified points are linearly interpolated. Then, the crop coefficient curve for bare soil is overlaid on the crop coefficient curve, and the higher value at each day is chosen as the effective Kc, as shown in Figure 13. This step is necessary, as the soil dominates the ET of the field in the early stages of plant growth.

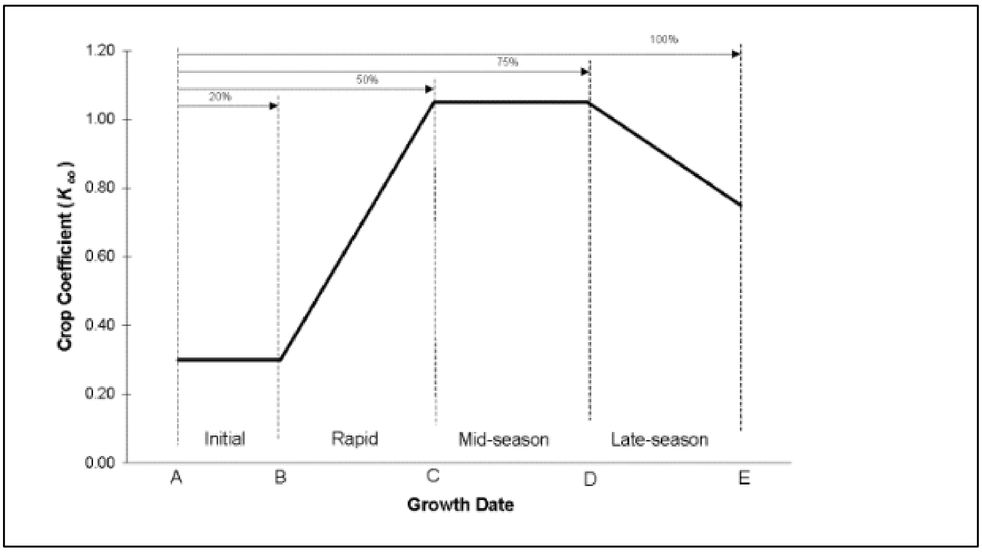


Figure 12. Construction of the crop coefficient
(Source: http://biomet.ucdavis.edu/Evapotranspiration/CropCoef/Kc.pdf)

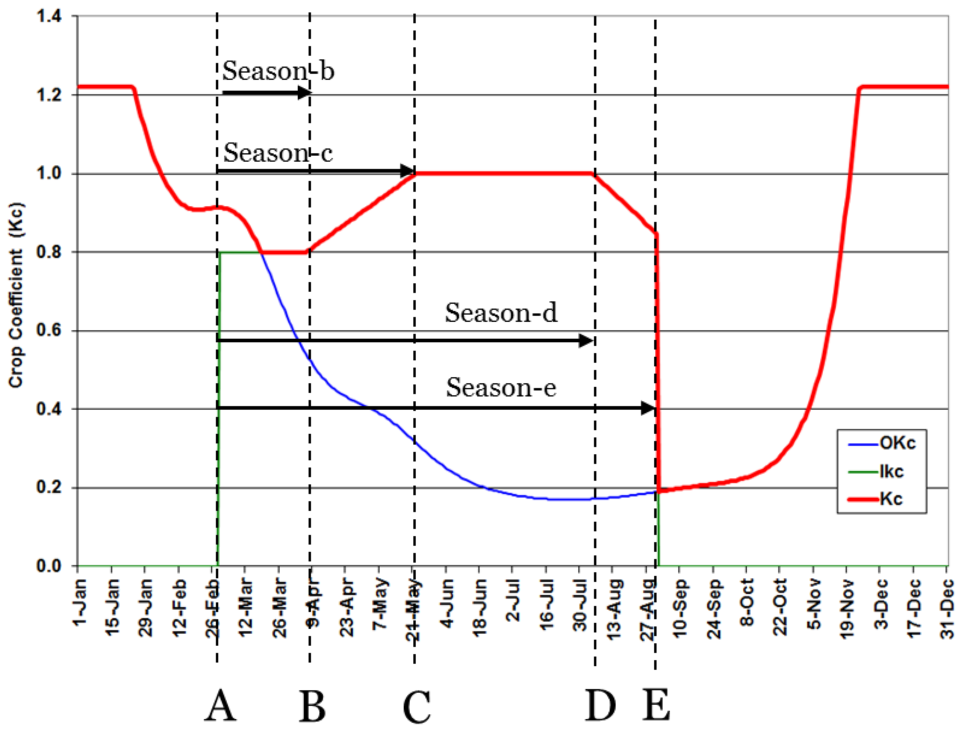


Figure 13. Combination of soil Kc (Blue) and crop Kc (Green) to yield effective Kc (Red)
(Crop shown: peppers)

4.2 Daily Average Load

Next, the value of the effective crop coefficient curve for each day is multiplied by the estimated reference evapotranspiration ET_o (reference evapotranspiration accounts for weather variation) for that day, to produce an estimate of the effective crop evapotranspiration, ET_c. Finally, the estimated precipitation for the day is subtracted to arrive at an estimate for the water deficit for the day.

$$Water\ deficit(d) = \max\left(Kc_{soil}(d), Kc_{crop}(d)\right) * ETo(d) - Precipitation(d)$$

This water deficit is multiplied by the energy intensity of pumping operations to arrive at an estimate of the energy required to pump enough water to balance the daily deficit, and is divided by 24 to arrive at the average load required for pumping. This load estimate is made for every day of the year. However, at peak ET the equipment may not have the capacity to meet the demands of the daily deficit, and can only pump at its actual capacity. To rectify this, the energy that is required but cannot be provided in each day (energy required – (pumping capacity * 24)) is summed, and this energy is redistributed to earlier and later in the season, so that the total water applied for the season matches the crop requirements.

$$\begin{aligned} Daily\ average\ load(d) &\\ &= \min\left(\frac{Water\ deficit(d) * energy\ intensity}{24}, pumping\ capacity\right) \\ &+ adjustements\ from\ days\ where\ water\ demand\ exceeds\ capacity(d) \end{aligned}$$

Finally, the demand response potential is calculated by de-rating the average load on days where the average load is at or near capacity. Based on the event length (EL, hours) and recovery horizon (RH, days) specified, the available load shift is calculated as the amount of load which can be shifted during the event and made up during the recovery horizon. *EL* refers to the length of the DR event and *RH* refers to the duration that the crop can tolerate low soil moisture before it is permanently damaged.

$$DR\ Potential(d) = \begin{cases} load(d), & \dfrac{capacity}{load(d)} > \dfrac{RH * 24}{RH * 24 - EL} \\ load(d) * \dfrac{24 * RH}{EL} * \left(\dfrac{\dfrac{capacity}{load(d)} - 1}{\dfrac{capacity}{load(d)}}\right), & 1 < \dfrac{capacity}{load(d)} < \dfrac{RH * 24}{RH * 24 - EL} \\ 0, & \dfrac{capacity}{load(d)} = 1 \end{cases}$$

In the equation above $\frac{EL}{24*RH}$ is defined as *shed ratio* and $\frac{Capacity}{Load(d)}$ is defined as *capacity ratio.*

Figure 14 is a graphical representation of the equations above, with each region labeled. When the daily load is significantly lower than the pumping capacity (capacity ratio>>1), DR potential is equal to the daily load. Having excess pumping capacity allows growers to shut down their pumps completely and recover from low soil moisture within the desired recovery horizon after a DR event. As the daily load reaches pumping capacity ($1 < capacity\ ratio < {}^{1}/_{shed\ ratio}$), growers have less excess capacity and require more time to bring the soil moisture back to desired levels after a DR event. Therefore, pumping capacity needs to be de-rated when calculating the DR potential. In this case, growers cannot have a complete shutdown since they need to maintain a minimum soil moisture level in order to be able to recover to the desired level within the recovery horizon after the DR event. Once the capacity ratio reaches unity or below, DR potential drops to zero since the pumps need to run flat to satisfy the crop demand.

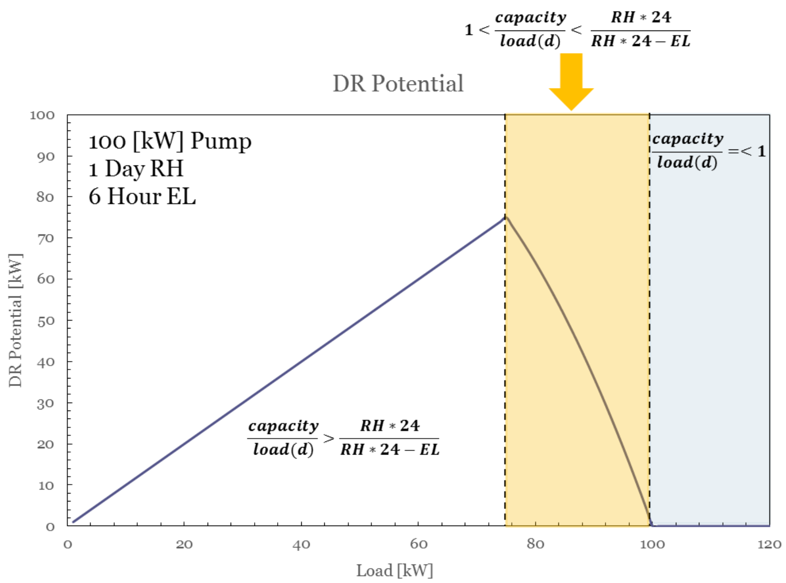


Figure 14. Graphical representation of the DR potential calculation

Figure 15 shows how the recovery horizon can affect demand response potential. A longer recovery horizon reduces the shed ratio and allows growers to shed more load, even when their pumps are running close to rated capacity.

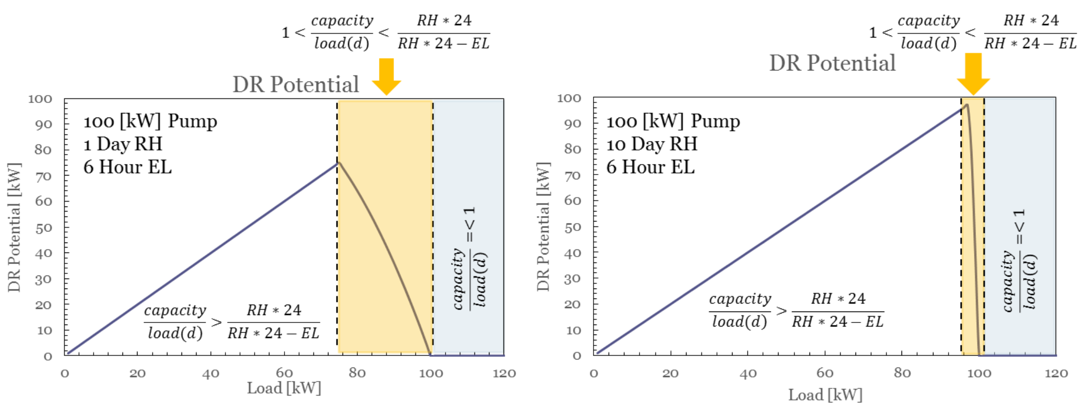


Figure 15. Impact of the recovery horizon on demand response potential

5 Appendix I

Crop Specific Information

Crop coefficients used in the back-end calculations.

Crop Name	% season B	% season C	% season D	KcB	KcC	KcD	KcE	Typical Planting Month	Typical Planting Day	Typical Harvest Month	Typical Harvest Day
Alfalfa (cycle)	7	30	100	0.40	1.15	1.15	0.40	6	20	7	20
Artichokes	6	19	90	0.65	0.65	0.65	0.65	7	1	5	1
Asparagus	12	25	95	0.25	1.00	1.00	0.25	1	1	12	31
Barley	20	45	75	0.70	1.10	1.10	0.15	11	1	5	31
Beans (pinto)	24	40	91	0.20	0.90	0.90	0.10	6	15	9	30
Beans (dry)	24	40	91	0.20	1.00	1.00	0.10	6	15	9	30
Beans (green)	22	56	89	0.80	1.00	1.00	0.85	3	1	5	31
Beets (table)	25	60	90	0.30	0.90	0.90	0.90	4	1	6	20
Broccoli	20	50	83	0.30	1.00	1.00	0.80	3	15	7	1
Cabbage	25	63	88	0.30	1.00	1.00	0.85	8	1	11	15
Carrots	20	50	83	0.85	0.95	0.95	0.80	1	15	5	15
Celery	15	40	90	0.80	0.95	0.95	0.95	9	15	1	15
Corn (grain)	20	45	75	0.20	1.05	1.05	0.60	5	1	9	30
Corn (silage)	20	45	100	0.20	1.00	1.00	1.00	5	1	8	15
Cotton	15	25	85	0.35	0.95	0.95	0.50	5	15	10	15
Cucumber	19	47	85	0.80	0.85	0.85	0.85	3	15	6	15
Eggplant	23	54	85	0.80	0.90	0.90	0.85	4	1	11	15

Crop Name	% season B	% season C	% season D	KcB	KcC	KcD	KcE	Typical Planting Month	Typical Planting Day	Typical Harvest Month	Typical Harvest Day
Flax	17	45	80	0.20	1.10	1.10	0.25	4	1	7	31
Grains (small)	20	45	75	0.33	1.10	1.10	0.15	11	1	5	31
Grains (winter)	20	45	75	0.33	1.05	1.05	0.15	11	1	5	31
Lentil	24	40	91	0.20	1.00	1.00	0.10	6	15	9	30
Lettuce	25	65	90	0.80	0.80	0.80	0.80	3	15	7	15
Melon	21	50	83	0.80	0.95	0.95	0.75	4	1	11	15
Millet	14	36	75	0.30	1.00	1.00	0.30	11	1	5	31
Mustard	25	63	88	0.30	1.00	1.00	0.85	8	1	11	15
Oats	20	45	75	0.33	1.10	1.10	0.15	11	1	5	31
Onion (dry)	10	26	75	0.55	1.20	1.20	0.55	3	1	10	1
Onion (green)	25	70	90	0.55	1.20	1.20	0.55	3	1	8	1
Peas	20	47	83	0.20	1.00	1.00	1.00	3	1	5	31
Peppers	20	45	85	0.80	1.00	1.00	0.85	3	1	8	31
Potato	20	45	78	0.80	1.10	1.10	0.70	4	15	8	15
Radishes	20	45	85	0.80	0.85	0.85	0.75	4	1	5	1
Rice	24	37	86	1.20	1.05	1.05	0.80	5	15	9	30
Safflower	17	45	80	0.20	1.05	1.05	0.25	4	1	7	31
Sisal	17	45	80	0.20	1.05	1.05	0.25	4	1	7	31
Sorghum	16	42	75	0.20	1.05	1.05	0.50	4	1	11	15
Spinach	33	67	92	0.80	0.95	0.95	0.90	11	15	1	31
Squash	20	50	80	0.52	0.90	0.90	0.70	1	15	4	15

Crop Name	% season B	% season C	% season D	KcB	KcC	KcD	KcE	Typical Planting Month	Typical Planting Day	Typical Harvest Month	Typical Harvest Day
Strawberries w/mulch	15	45	80	0.20	0.70	0.70	0.70	5	1	9	30
Sugarbeet	15	45	80	0.20	1.15	1.15	0.95	3	15	9	30
Sunflower	20	45	80	0.20	1.10	1.10	0.40	5	1	9	10
Sweet Potatoes	20	45	78	0.80	1.10	1.10	0.70	4	15	8	15
Tomato	25	50	80	0.30	1.10	1.10	0.65	4	1	8	31
Vegetables	33	67	92	0.80	0.90	0.90	0.90	3	1	8	31
Wheat	20	45	75	0.33	1.10	1.10	0.15	11	1	5	31
Watermelon	20	50	75	0.80	1.00	1.00	0.75	4	1	11	15
Alfalfa (annual)	25	50	75	1.00	1.00	1.00	1.00	1	1	12	31
Improved Pasture	25	50	75	0.95	0.95	0.95	0.95	1	1	12	31
Turfgrass (cool-season)	25	50	75	0.80	0.80	0.80	0.80	1	1	12	31
Turfgrass (warm-season)	25	50	75	0.60	0.60	0.60	0.60	1	1	12	31
Almonds	0	50	90	0.55	1.15	1.15	0.65	3	1	10	15
Apple	0	50	75	0.55	1.15	1.15	0.80	4	1	11	15
Table grapes	0	25	75	0.45	1.05	1.05	0.35	4	1	11	1
Wine grapes	0	25	75	0.45	0.80	0.80	0.35	4	1	11	1
Kiwifruit	0	22	67	0.30	1.05	1.05	1.00	5	1	10	31
Stone fruits	0	50	90	0.55	1.15	1.15	0.65	3	1	10	15
Walnuts	0	50	75	0.55	1.15	1.15	0.80	4	1	11	15
Avocado	0	33	67	0.70	0.70	0.70	0.70	1	1	12	31

Crop Name	% season B	% season C	% season D	KcB	KcC	KcD	KcE	Typical Planting Month	Typical Planting Day	Typical Harvest Month	Typical Harvest Day
Citrus	0	33	67	1.00	1.00	1.00	1.00	1	1	12	31
Citrus (desert)	0	33	67	0.90	0.90	0.90	0.90	1	1	12	31
Date Palm	0	33	67	0.95	0.95	0.95	0.95	1	1	12	31
Evergreen	0	33	67	1.15	1.15	1.15	1.15	1	1	12	31
Olives	0	33	67	0.80	0.80	0.80	0.80	1	1	12	31
Sudan grass	33	67	87	0.50	1.15	1.15	1.10	7	18	9	30
Sugarcane	0	17	68	0.40	1.25	1.25	0.75	5	15	5	14